Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of	)	
Part 90 Rules Governing	)	
Location and Monitoring Service to	)	File No. ______________
Promote Greater Utilization to Serve	)	
Critical Infrastructure (including ITS),	)	
Public Resources and Facilities,	)	
And Homeland Security	)	

To The Commission

Petition for Rule Making

(the ATLIS 900 MHz Petition)

Exhibit Submitted Under §0.459 and §0.457

Warren C. Havens and Telesaurus Holdings GB LLC (together, "Petitioner") hereby submit, as attachments hereto, Exhibit 6 to the above-captioned Petition for Rule Making (the "Petition") concurrent with the filing of the Petition.

Exhibit 6 is hereby submitted under a request under §0.459 of the Commission Rules that Exhibit 6 and its contents be withheld from public inspection for a period of two years, including but not limited to the reason that their contents fall within the scope of §0.457(d). Regarding Exhibit 6, the following information is provided in accordance with §0.459:

1. The specific information for confidential treatment is all of the information contained in the Exhibit 6 including the names of the component documents and the authors and other parties named therein (together, the "Confidential Information").

2. The proceeding is the above-captioned Petition for Rule Making.

3. All of the Confidential Information is commercial in nature, subject to non-disclosure contracts, and involve trade secrets, or is privileged.

4. All of the Confidential Information concerns wireless services that are subject to competition, namely, the Multilateration Location and Monitoring Service.

5. Disclosure of the Confidential Information would (i) cause a breach by Petitioner of the several non-disclosure contracts it is a party to, including but not limited to such contracts with Brian Agee PhD and Metricom (whose assets and obligation have been assumed by another party pursuant to a bankruptcy proceeding), and such breaches could also damage Petitioner's commercial relationship including with the other parties to such agreements, (ii) damage Petitioner's business plans and prospects, (iii) unfairly provide at no cost valuable and time-sensitive information to competitors which cost Petitioner substantial time and expense to develop, and provide to competitors opportunities to attempt to impede Petitioner's business plans and prospects.

6. As noted above, the Confidential Information is subject to non-disclosure contracts with the other parties that have knowledge of the Confidential Information. These are legally binding agreements, with terms common for such agreements used by communications companies, that impose requirements on the signing parties to carefully keep certain communications and information exchanged confidential.

7. The Confidential Information has not been disclosed and is not available to the public or to parties other than the FCC (via this filing) and those with whom Petitioner has the above-mentioned non-disclosure contracts.

8. The above-requested two-year confidentiality period is warranted since either (i) the above-noted non-disclosure contracts obligate Petitioner to keep the Confidential Information confidential for most of that period of time, and/or (ii) not before the end of that time does Petitioner expect the business that involves the Confidential Information to be developed to the stage that the Confidential Information, or superceding information of the same character, would be placed into the public domain by Petitioner.

Exhibit 6, the subject of the above request under §0.459, is attached hereto.

Respectfully submitted, April 9, 2002,

Warren Havens

Warren C. Havens,
for himself and as President of
Telesaurus Holdings GB, LLC

2509 Stuart Street, Berkeley, CA 94705
Ph: 510-841-2220 Fx: 510-841-2226

Exhibit 6

There are four parts of this Exhibit 6:

A The "Joint Project" agreement that was executed by the parties* listed in the agreement, including Petitioner (most section's text deleted)*

B. The Joint Project agreement's Attachment A, Statement of Work,

C. A summary slide-show report (one of several) of substantial work under the Statement of Work that was completed before this Joint Project was suspended, then ended, due to the bankruptcy of Metricom (the slide show outlined a much longer narrative report), and

D. A related discussion of issues regarding technology development for LMS Multilateration licensed operations.

* Deletions in below items are indicated by ellipsis marks.

See text of the Petition for the significance of this Exhibit.

Generally, the documents in this Exhibit reveal (as do others not presented here) the major due diligence by Petitioner in seeking technical solutions to operation of LMS Multilateration systems in the 902-928 MHz band in the presence of Part 15 devices.

The assessment of this matter, as well as potential solutions, required high-level complex analyses. No equipment vendor was willing to undertake such analyses. Petitioner thus had to undertake such analyses on its own, hiring consultant engineering, including for a joint study with Metricom which (at the time) was the entity that had by far the major Part 15 network in the nation in the 902-928 MHz band: the network that posed to most difficult Part 15 interference problem for LMS Multilateration system operations. [1]

In sum, while partial solutions appeared possible using very advanced techniques, not yet employed in any commercial wireless, including upcoming "3G" technology, the scope of work, risks, and predictable time and costs involved, were daunting, especially for a very small business as is the Petitioner. See more on this in the Petition text.

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* Note: one party is Telesaurus VPC LLC, an entity set up and majority owned and controlled by Warren C. Havens and used for certain operations supportive of his wireless businesses.

1 Metricom has since ceased operations, filed bankruptcy, and was sold. The purchaser, Aerie, has briefly discussed with Petitioner its plans to partially revive the Metricom Part 15 ventures in the 902-928 MHz band, but has given few details.

Exhibit 6, Part A

Joint Metricom/Telesaurus Project Agreement

This Agreement . . . . entered into by and between Brian G. Agee, Ph.D, P.E. ("Dr. Agee"), an individual with an address of . . . . , Metricom, Inc, ("Metricom"), a Delaware corporation having its principal place of business at 333 West Julian Street, San Jose, California 95110, its successors and its subsidiaries worldwide, and Telesaurus-VPC LLC ("Telesaurus"), a Delaware Limited Liability Company, whose current principal place of business is located at 2509 Stuart Street, Berkeley, California, USA. Metricom and Telesaurus shall be jointly referred to hereafter as "Clients."

1 Projects * * * *

2 Payment for the Projects * * * *

3 Term * * * *

4 Relationship of the Parties * * * *

5 Warranties; Limitation of Liability * * * *

6 Ownership * * * *

7 Confidentiality

This section 7 shall serve to amend all past agreements and understandings between Dr. Agee and each Client with respect to confidentiality of information disclosed by such Client to Dr. Agree. Prior to execution of this Agreement, Dr. Agee has obtained information from each Client which such Client considers, and Dr. Agee has agreed to keep, confidential (essentially, not to be disclosed to any other party) ("Client Confidential Information"). In addition, during the term of this Agreement, each Client may transmit to Dr. Agee additional Client Confidential Information. Each Client agrees that during the term of this Agreement, it will designate to Dr. Agee which information it provides to Dr. Agee is Client Confidential Information, and which is Client-Provided Project Information. All information disclosed to Dr. Agee by Clients in connection with the performance of the Projects other than information designated in writing as Client-Provided Project Information shall be considered Client Confidential Information, including but not limited to the data in Clients's files and Clients's current and future business plans (that is not so designated). . Dr. Agee agrees to take all responsible steps to ensure that such Client Confidential Information is not disclosed in whole or in part to any other party (including the other Client) and agrees to keep such Client Confidential Information completely confidential and to refrain from disclosing such information, except to his employees and agents who have a need to know and who are under written confidentiality terms no less restrictive than those found in this agreement. This prohibition on disclosure and use shall not apply to (a) information which was previously known to Dr. Agee (b) information lawfully received by Dr. Agee from a third party who was not under an obligation of confidentiality, or (c) information which already is, or becomes in the public domain other than by a disclosure prohibited hereunder.

8 Termination * * * *

9 Miscellaneous * * * *

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the date first written above.

Metricom, Inc. "Metricom/Clients"	Brian G. Agee, Ph.D., P.E. "Dr. Agee"
By: ______________________	By: ______________________
Michael W. Ritter, Ph.D. Chief Technical Officer	
Telesaurus-VPC, LLC "Telesaurus/Clients"	
By: ______________________	
Warren C. Havens, President	

[Original was fully executed.]

Exhibit 6, Part B

Exhibit A: Statement of Work

1 Project Description

Dr. Agee shall investigate engineering benefits of cooperation between Metricom and Telesaurus to develop and exploit the Multilateral LMS (M-LMS) band overlying the 902-928 MHz ISM (Part 15) band. A number of potential advantages can accrue to both sides in such an endeavor. As the largest, most aggressive, and most successful user of the Part 15 bands, Metricom will be most affected, and will most strongly affect, build-out of M-LMS equipment and services by Telesaurus. Conversely, both organizations have the most to gain by cooperating to mitigate or even benefit from this build-out. Potential benefits provided under partially cooperative strategies include:

- demonstrated compliance with [1, ¶ 38, pp. 4717], regarding voluntary cooperation between Part 15 and M-LMS users[2]; and
- elimination and/or mitigation of co-channel interference (CCI) from either party's network, without costly build-out of equipment to serve areas operating in presence of such services.

Even stronger benefits can be provided if the two parties combine these networks. Potential benefits to Metricom, include the following.

- improved user/network capacity, quality of service (QoS), grade of service (GoS), and areal coverage per poletop, by allowing operation of Metricom poletops and subscriber equipment at the much higher (47-to-57 dBm) EIRP limit allowed in the M-LMS band;
- improved capacity, QoS, GoS, and coverage on 902-928 MHz subscriber links <u>and</u> 2.40-2.48 GHz backhaul links, by deploying poletop equipment at antenna heights above 5-to-15 meters;
- reduced equipment costs, due to relaxed FHMA bandwidth limits in the M-LMS band;
- access to location and monitoring services to be provided in the M-LMS band, including Telematics applications; and
- provision of service to Ricochet users in geographical areas covered by LMS equipment.

Similarly, potential benefits to Telesaurus, include the following.

- potential access to extensive backhaul, infrastructure equipment, technology, and intellectual property (IP) developed, deployed, and proven by Metricom in their 1G and 2G deployments;

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[2] In fact, this study will itself constitute voluntary cooperation between Part 15 and LMS band users.

- access to Metricom engineering services to speed development of equipment for LMS services;
- access to the Ricochet brand and established service organization to speed acceptance of Telesaurus services in the marketplace; and
- seamless exploitation of the 902-904 MHz and 909.75-919.75 MHz subbands allocated for nonmultilateral LMS operation [1, ¶ 39, pp. 4717-4718.

In addition, a combined Telesaurus/Metricom entity could more easily enter new markets and applications, e.g., fixed point-to-multipoint cellular networks in the 902-928 MHz bands, for which neither party is currently well positioned.

This study will address engineering benefits to be obtained under several internetwork cooperation strategies, including:

- *uncooperative strategies*, where each party deploys completely independent networks, without cooperation from the other party, but with knowledge of physical parameters of the others' network;
- *passive cooperation strategies*, where Telesaurus and Metricom operate independent networks under specific preset guidelines put in place to minimize internetwork co-channel interference (CCI);
- *active cooperation strategies*, where Telesaurus and Metricom operate interdependent but (nominally) separate networks, with specific communication and control modes added to minimize internetwork CCI; and
- *fully integrated networking strategies*, where Telesaurus and Metricom join networks and maximally exploit advantages offered by both parties.

In each scenario, various CCI mitigation strategies will be considered, including dense poletop deployments; passive spreading strategies; reactive spreading strategies; and "credible" degrees of polarization/spatial adaptivity at M-LMS Bases and subscriber nodes, and at Metricom poletops and subscriber nodes. Specific network attributes analyzed here can include:

- subscriber link capacity (Mbps/link);
- poletop and/or M-LMS base station capacity (Mbps/node, bps/Hz/node), and (rough) cost/bit;
- absolute (bps/Hz) and areal (bps/Hz/km^2) M-LMS network capacity;
- poletop and/or M-LMS base station density required to meet target capacity requirements (TBD at the project start);
- outage and fragment error probability; and
- Areal exclusion zone generated M-LMS Mobiles and Bases (in which Part 15 devices are unable to operate).

Performance will be assessed for two-to-three general network topologies, to be decided at the start of the project, for the Ricochet[2] airlink and network architecture described in [2], and for a TBD Telesaurus airlink and network[3].

[1] FCC Report and Order 95-41, Adopted February 3, 1995

[2] M. Ritter, B. Friday, "The Architecture of Metricom's MicroCellular Data Network (MCDN) and Details of its Implementation as the Ricochet and Ricochet[2] Wide-Area Mobile Information Access Service," v 1.5, 28 Nov 1998, *Metricom Confidential Information*

2 Project Tasks

This project is comprised of five Tasks:

- a *Planning and Management Task*, finalizing exemplary Metricom and Telesaurus network topologies, subscriber link parameters, CCI mitigation methods, and performance criteria to be considered on the Project, and providing twice-monthly status meetings during the Project;
- a *Testbed Development and Early Analysis Task*, developing a testbed to be used in performance assessment tasks, and performing a set of "early" analyses to determine rough bounds on the performance of Metricom and Telesaurus networks under simplified uncooperative and fully-integrated communication scenarios;
- an *Uncooperative Internetwork Performance Task*, analyzing effects of uncooperative system deployment on the Metricom Ricochet[2] network, and on hypothesized Telesaurus networks;
- a *Cooperative Internetwork Performance Task*, analyzing improvements provided by simple cooperation strategies in which Telesaurus and Metricom operate independent networks with passive and/or active cooperation to minimize interference between networks; and
- A *Fully Integrated Network Performance Task*, analyzing performance of a hypothetical joint Telesaurus and Metricom network that maximally exploits advantages offered by both parties.

Work to be performed under each of these Tasks is described in more detail below.

2.1 Planning and Management Task (80 hrs)

Dr. Agee shall finalize exemplary Metricom and Telesaurus network topologies, subscriber link parameters, CCI mitigation methods, and performance criteria to be considered on the Project. Dr. Agee shall also provide twice-monthly status meetings over the course of the Project, both in person at Metricom's facility on a monthly basis, and via telephone conference in between physical meetings.

Relevant Metricom PHY and MAC parameters shall be based on the airlink description provided in [2], with poletops deployed in a rectangular pattern and with 1 mile spacing between

[3] If desired, this analysis can also be extended to include hypothetical 4G Metricom networks.

poletops[4]. Relevant Telesaurus PHY parameters shall be based on a straw-man airlink architecture designed to provide high capacity and low outage in the presence of interference provided by the Ricochet[2]. Three Telesaurus network topologies shall be considered:

- a *macrocellular point-to-multipoint (P-MP) topology* where a network of widely separated (5-50 mile) M-LMS Base Stations are deployed over a wide geographical area and used to communicate with a set of randomly deployed set of M-LMS mobiles.
- a *microcellular/roadside P-MP topology* where a network of closely separated (1-5 mile) M-LMS Base Stations are deployed over a either a wide geographical area (microcell topology), or along a line (roadside topology), and used to communicate with a set of M-LMS mobiles; and
- a *roadside backhaul topology* where a line of closely spaced M-LMS relay nodes are used to backhaul data collected as part of a Telematics or ITS application.

Alternate networks shall also be considered if proposed by Metricom or Telesaurus during this Task.

These parameters and analysis goals shall be documented in a Kickoff Briefing given at Metricom's facility.

2.2 Testbed Development and Early Analysis Task (160 hrs)

Dr. Agee shall develop an internetwork analysis testbed to assess (PHY) performance of the Metricom and Telesaurus networks in subsequent Tasks. Dr. Agee shall also use this testbed (or a preliminary version of this testbed) to determine rough bounds on the performance of Metricom and Telesaurus networks under simplified uncooperative and fully-integrated communication scenarios.

Relevant Metricom PHY and MAC parameters shall be based on the airlink description provided in [2], with poletops deployed in a rectangular pattern and with 1 mile spacing between poletops[5]. Relevant Telesaurus PHY parameters shall be based on a straw-man airlink architecture designed to provide high capacity and low outage in the presence of interference provided by the Ricochet[2]. Three Telesaurus network topologies shall be considered:

- a *macrocellular point-to-multipoint (P-MP) topology* where a network of widely separated (5-50 mile) M-LMS Base Stations are deployed over a wide geographical area and used to communicate with a set of randomly deployed set of M-LMS mobiles.
- a *microcellular/roadside P-MP topology* where a network of closely separated (1-5 mile) M-LMS Base Stations are deployed over a either a wide geographical area (microcell topology), or along a line (roadside topology), and used to communicate with a set of M-LMS mobiles; and
- a *roadside backhaul topology* where a line of closely spaced M-LMS relay nodes are used to backhaul data collected as part of a Telematics or ITS application.

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[4]Representative 4G airlinks may be introduced and analyzed on the *Fully Integrated Network Performance Task.*
[5]Representative 4G airlinks may be introduced and analyzed on the *Fully Integrated Network Performance Task.*

Alternate networks shall also be considered if proposed by Metricom or Telesaurus during this Task.

Initial analysis results shall be based on modified Hata median pathloss models, suburban deployment, and log-normal, Rayleigh, or Suzuki (combined) random shadowing and fading, with link capacities estimated/bounded using Shannon-like capacity arguments, and with margin and/or inefficiency added to account for specific airlinks and/or modulation formats, and degradation due to blockage/attenuation and power management error.

Specific performance criteria developed here may include:

- subscriber link capacity (Mbps/link);
- poletop and/or M-LMS base station capacity (Mbps/node, bps/Hz/node), and (rough) cost/bit;
- absolute (bps/Hz) and areal (bps/Hz/km^2) M-LMS network capacity;
- poletop and/or M-LMS BS density required to meet target capacities (TBD at the project start);
- outage and fragment error probability; and
- areal exclusion zone formed near M-LMS Mobiles and Bases.

Specific performance criteria shall be finalized on this phase of the Task.

The internetworking testbed shall be focused on high-level modelling of the Ricochet and Telesaurus network, in order to assess performance criteria described above. The testbed shall use modelling and simulation tools readily available to Dr. Agee.

2.3 Uncooperative Internetwork Performance Task (120 hrs)

Dr. Agee shall analyze effects of uncooperative deployment of Metricom Ricochet[2] and M-LMS Telesaurus networks. It is assumed that the Ricochet network will counter M-LMS interference using existing capabilities of the Ricochet network; deployment strategies to improve tolerance to M-LMS interference; or new airlink capabilities to excise uncooperative CCI, e.g., spatial or polarization diversity. Similarly, it is assumed that the M-LMS network will incorporate specific features to tolerate or resist uncooperative CCI introduced by the Ricochet network.

2.4 Cooperative Internetwork Performance Task (80 hrs)

Dr. Agee shall analyze benefits provided by cooperation between Metricom and Telesaurus networks. Two classes of strategies shall be considered:

- passive cooperation strategies, in which Telesaurus and Metricom operate independent networks under specific (TBD) operating guidelines or general timing or system information provided within either network, in order to reduce internetwork CCI.
- active cooperation strategies, in which Telesaurus and Metricom operate inderdependent networks, e.g., employing internetwork communication to reduce CCI or enhance other network capabilities.

Potential cooperation strategies shall be proposed at the beginning of this Task, and agreed to by both Metricom and Telesaurus, before being analyzed under this Task. Agreement to study effect of any given cooperation strategy shall in no way constitute an agreement by either Metricom or Telesaurus to adopt such a strategy.

2.5 Fully-Integrated Network Performance Task (120 hrs)

Dr. Agee shall analyze performance of a hypothetical joint Telesaurus and Metricom network that maximally exploits advantages of both networks. A high-level joint network architecture, employing M-LMS PHY elements, Metricom MAC, DLL, and network elements, and Metricom PHY elements in the nonmultilateral LMS band, shall be proposed, and traffic requirements of a joint system shall be generated. Performance of this system shall be analyzed and compared to performance of uncooperative and partially cooperative strategies analyzed on previous Tasks. Agreement to study effects of this proposed network or of any other fully-integrated networking strategy shall in no way constitute an agreement by either Metricom or Telesaurus to adopt that network or strategy.

3 Project Deliverables

Deliverables shall consist of

- a Kickoff Briefing, to be presented at the start of the Project, proposing exemplary Metricom and Telesaurus network topologies, subscriber link parameters, CCI mitigation methods, acrtive/passive cooperation strategies, and performance criteria to be considered on the Project.
- a Final Briefing, to be presented at the end of the Project, describing results of the four tasks; and
- a Final Report, provided one month after the Final Briefing, providing additional written commentary on results of the Project.

4 Project Cost and Schedule

Project Cost and Schedule is shown in Figure 4.1 below. Total cost for this Project phase is assumed to be limited to $112K ($56K/party), comprising 560 hours of labor expenses for execution of Project Tasks. Schedule for the Project is four (4) months, with an assumed Project completion date of January 19, 2000, assuming a start date of September 19, 2000. The project is bid on a Level of Effort basis.

Figure 4.1: Project Cost and Schedule

5 Dr. Agee Intellectual Property

A **General Programs and Routines**. Over the course of this Project, Dr. Agee may provide Customers with Deliverables containing general programs and routines that are the property of Dr. Agee. This property may include:

- General matrix and vector manipulation scripts, including Modified Gram-Schmidt Orthogonalization (MGSO) scripts for fast QRD, rank-reducing MGSO/QRD scripts, fast SVD scripts, etc.

- Generic signal generation scripts, e.g., PSK/QAM signal generation scripts; OFDM/multitone generation scripts; CDMA generation scripts, etc.
- Generic filter design scripts.
- General filter/array adaptation scripts, e.g., to instantiate nonblind LS and nonproprietary adaptation algorithms.
- Generic channel analysis and simulation scripts, e.g., Longley-Rice, two-ray round-Earth, Hata, Rayleigh, Rice, and Suzuki models, and AR/MIMO extensions of those models for dynamic channels and diversity communication links.
- Generic performance analysis scripts, including BER/SER, SINR, max-SINR, link/network capacity, Cramer-Rao bounds, etc.
- General scripts for computing complexity and throughput of general signal processing operations, e.g., FFT/IFFT operations, time-and-frequency based FIR filtering operations, general matrix operations, etc.
- Other MATLAB scripts performing general operations that do not directly pertain to IP developed for Customers, but which may be included in certain deliverables.

B **<u>Specific Intellectual Property Owned by Dr. Agee</u>**. Specific IP developed and owned by Dr. Agee, which may be relevant to the Project and which may be incorporated into Deliverables only upon execution of a non-exclusive royalty-bearing license agreement, includes:

- Interference and dynamics-resistant multitone modulation formats.
- Means for efficiently modulating, overlaying, and demodulating co-channel multitone waveforms with differing spectral efficiencies and interference/dynamics immunities.
- Means for adaptive transmit and receive processing to remove intertone interference from multitone waveforms.
- Time-division duplex (TDD) airlink layouts facilitating communications over long distances.
- Computationally-efficient S-CDMA modulation formats allowing adaptive despreading, timing/Doppler control, and interference mitigation in communication networks, and means for efficiently instantiating these modulation formats.
- Means for mitigating/exploiting fading, co-channel interference, and network self-interference in air interfaces employing extensions of FDMA and FDMA/TDMA standards, including GSM, IS-136, TETRA, DECT, and extensions/third-party modifications of those airlinks, involving redundant transmission and adaptive reception of information over transmission resources available to users in the airlink.
- Means for embedding and exploiting network, link/packet, and node-specific information in transmitted signals, and exploiting that information to provide unambiguous/secure detection, copy/separation, localization,and link/network optimization for users in the network;
- Means for rapidly acquiring, separating, or excising signal bursts in random access communication systems, based on combinations of inherent and induced properties of those bursts.

- Means for rapidly acquiring, separating, or excising signal bursts in random access communication systems, prior to fine carrier and/or timing synchronization to those bursts.
- Robust, high-capacity multipoint datagram networks employing diversity-adaptive wireless communications transceivers and network-level MIMO processing, and means for instantiating adaptive transceivers in such networks.
- Means for performing high-precision multilateral and single-site emitter geolocation under strong co-channel interference, using route calibration information and waveforms generated within the network infrastructure.
- Inventions specifically including, though not being limited to, any patent incorporating any of the preceding items in sections 5(A) and 5(B), or in the area of wireless optimization, for which any patent is pending, under preparation, or will be filed naming Dr. Agee as one of the inventors.

Exhibit 6, Part C

LMS/Part 15 Internetwork Interference Study Results-to-Date

ricochet

TELESAURUS Wireless Services

23 February 2001

Brian G. Agee, Ph.D., P.E.
1596 Wawona Drive, San Jose, CA 95125
408.269.3218, bgagee@pacbell.net

Project Status (pg 1 of 3)

- Baseline Part 15 simulator nearing completion
  - 10,000 square-kilometer (100km x 100km) network (target)
  - 18,000 poletops, 800 meter separation, ~hex layout, variable HAAT's (target)
  - User-specifiable subscriber density, uplink/downlink distribution (target)
  - **Interleaved, segregated, or overlapped uplink/downlink frequency channels (target)**
  - Hata pathloss with Suzuki (log-normal + Rayleigh) fading (nearing target)
  - Power management [optionally] enabled on uplinks and downlinks (exceeds early target)
  - 30 minute run time; 3 minutes for 50 km x 50 km network (exceeds target)
  - **Full modelling of <u>all</u> cross-links (<u>greatly</u> exceeds target)**
  - **22 Mbyte memory usage (<u>greatly</u> exceeds target!)**
- Hooks added & tested for interference mitigation, capacity enhancement
  - Capture of key spatial processing parameters (azimuth, cross-link SWNR, etc.), allows demonstration of spatial interference mitigation, GoS/QoS enhancement (target)
  - Multiple access at poletops (≥ 1 subscriber/poletop) to demo SDMA-like capacity enhancement (exceeds target)
  - **<u>Mesh</u> access from subscribers (≥ 1 poletop/subscriber) to demo link assignment optimization, MIMO capacity/QoS enhancement (<u>greatly</u> exceeds target)**

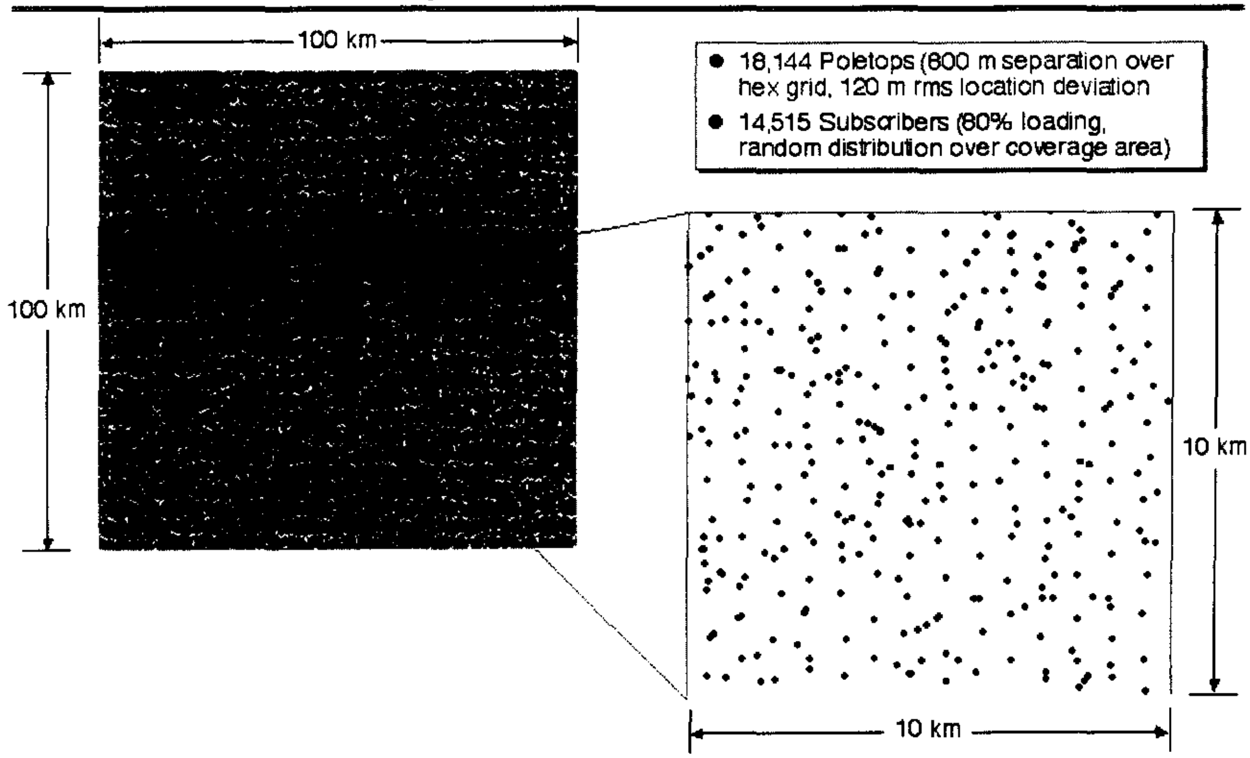
Project Status (pg 2 of 3)

- **Remaining "early" Part 15 simulation steps small**
  - FER quality metric (target — submodules developed)
  - Building penetration loss (target)
  - Full COST-231 pathloss (exceeds target — doable early)
  - Spherical two-ray pathloss to accurately suppress links at horizon (greatly exceeds target — now doable)
  - Cascaded gain, noise floor analysis to improve SWNR accuracy (correct error)
  - Uplink/downlink parameter merge (target)
  - Multielement array uplink/downlink (exceeds target — doable early)
  - More results plots (added as needed)
- **Conversion to LMS model straightforward**
  - Part 15 parameters placed in "p15" structure, easily changed to "lms"
  - Candidate uplink/downlink models nearing finalization, all frequency-channelized
  - Conversion from adhoc FHMA to TDD-FDMA simplifies model
  - Lighter network deployment simplifies model
- **Network overlays also expected to be straightforward**

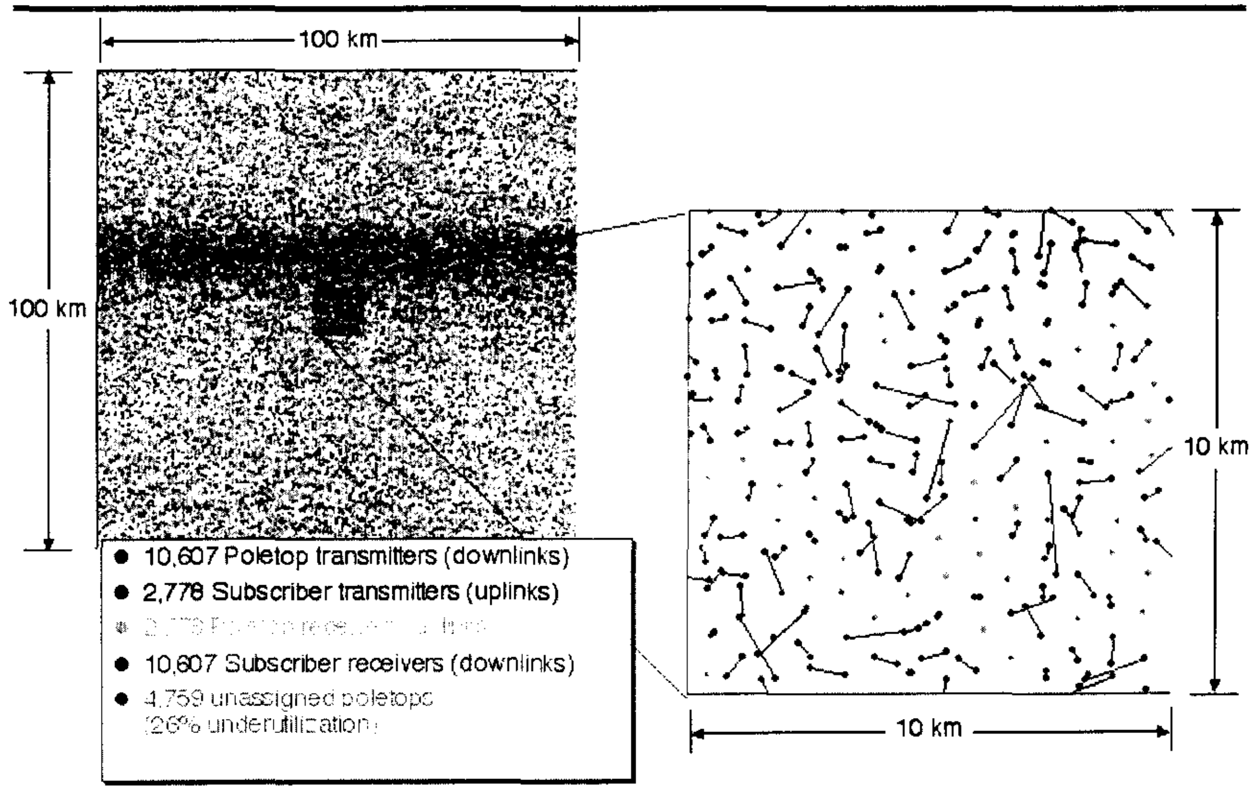
Project Status (pg 3 of 3)

- Schedule has slipped ~ 2 months
  - About where expected in early January
  - Due to isolated events (crisis with other client, family emergency)
  - Offset somewhat by progress on non-early tasks
- No cost risk – also underspent by ~ 2 months
- Current estimates:
  - Isolated Part 15 and LMS networks complete by early-to-mid March
  - Early interoperability results complete by mid-to-late March
  - Final simulation results by late April
  - Interoperability refinements, test plan by mid-to-late May
- Issues:
  - Metricom PO expires Feb 28 – asking for four month extension to cover schedule slip with 2 month margin
  - Need to understand effect of current [Metricom] cash-flow on Study

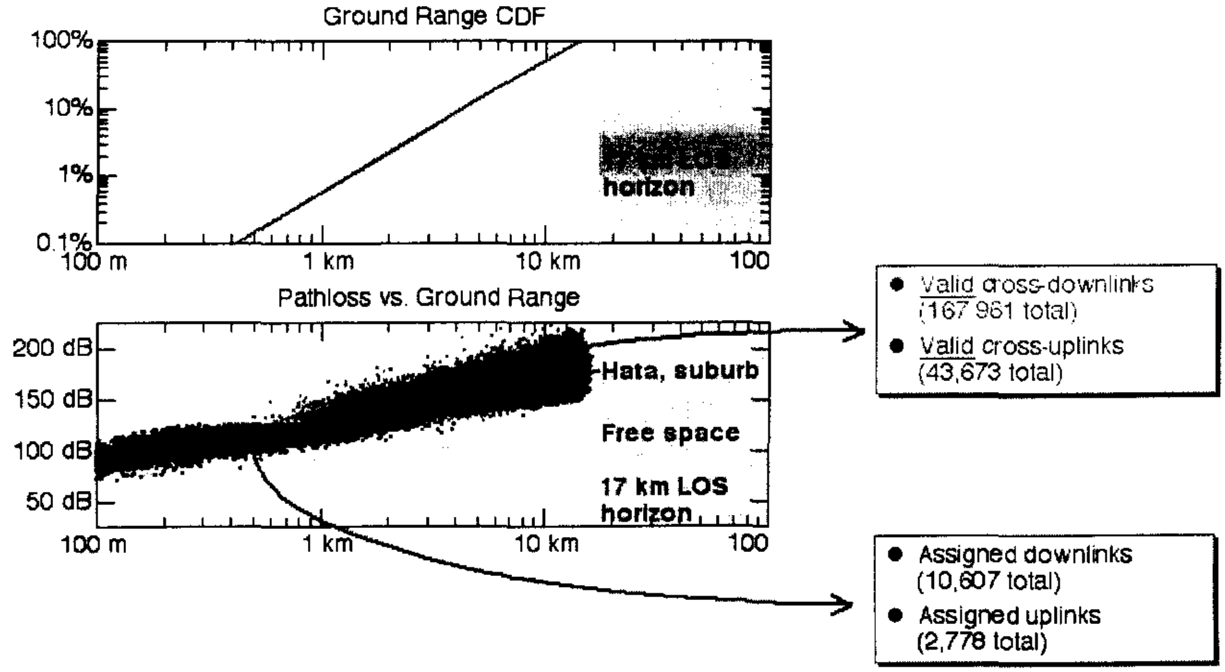
Example Large Network Layout



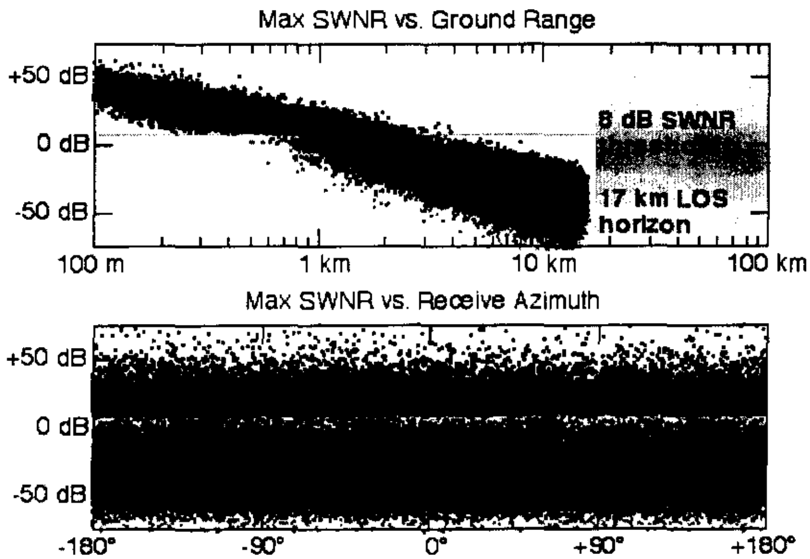
Link Assignments



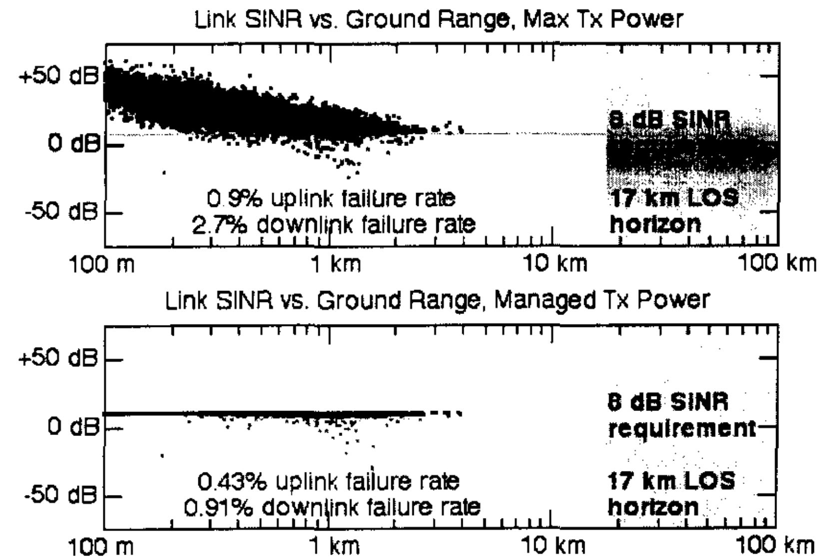
Range and Pathloss Distribution



Receive Signal-to-White-Noise Ratio, Max Transmit Power (36 dBm EIRP)



Link Signal-to-Interference-and-Noise Ratio, With and Without Tx Power Management



Mesh Link Assignment Example (Forward Hooks)

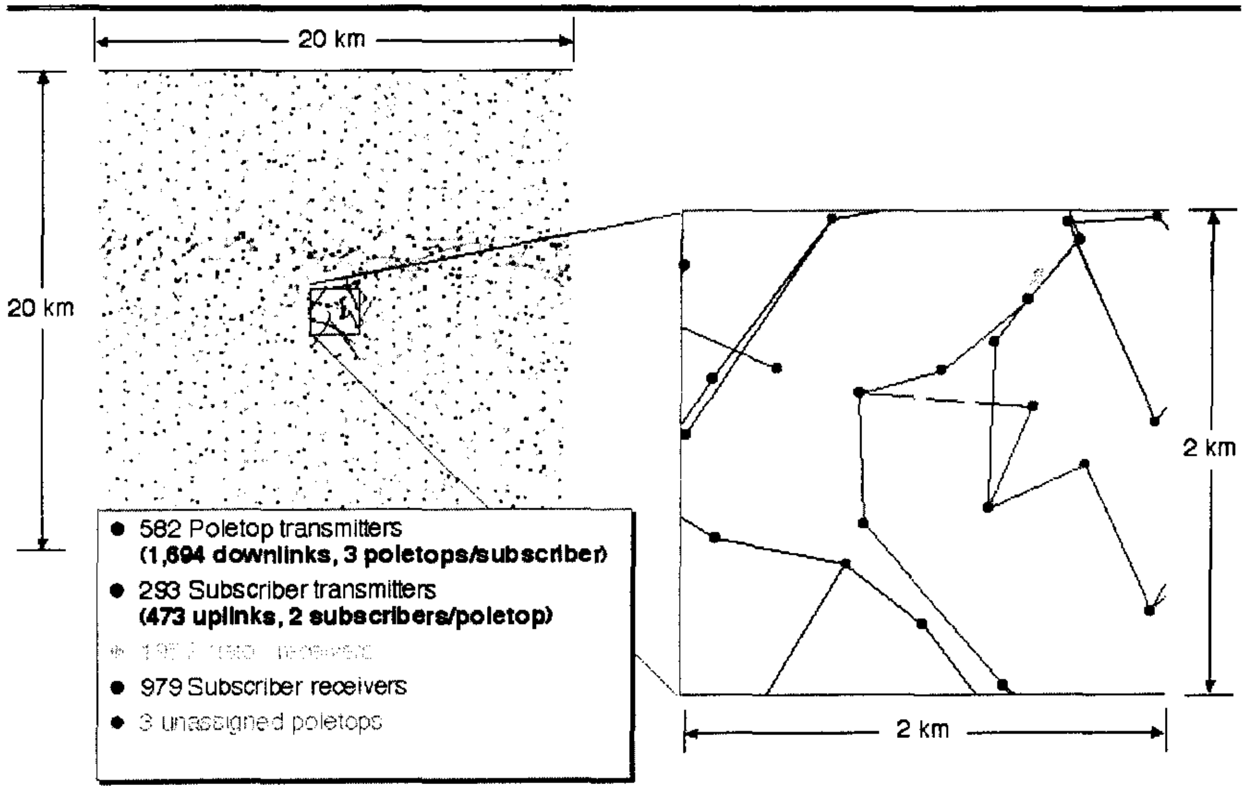


Exhibit 6, Part D

Utilization of the Multilateral LMS Band for Fourth-Generation Mobile Communication Services

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1 The Opportunity and the Challenge

The 902-928 MHz Location Monitoring and Services (LMS) band poses unique challenges — and unique opportunities — for *fourth generation* portable and mobile communication services. By itself, the LMS band has attributes that lends itself to high quality wireless services, including:

- a nationwide footprint, now consolidated over the 904-909.75 MHz and 919.75-928 MHz segments exclusively authorized for multilateral LMS (M-LMS) systems;
- high downlink (62 dBm aggregate EIRP) and uplink (52 dBm aggregate EIRP) radiated power limits, especially relative to incumbent users of the coincident 902-928 MHz band;
- reasonable out-of-band attenuation requirements (55 dB + P(dBW), compared to 43 dB + P(dBW) and 110 dB + P(dBW) for PCS and WCS bands, respectively);
- reasonable frequency stability requirements (2.5 ppm, e.g., ±2.3 kHz over the 902-928 MHz band);
- unrestricted limits antenna heights and modulation format, within power, out-of-band attenuation requirements, and frequency stability requirements described above;
- moderate-to-light restrictions on use of the band, in particular for delivery of mobile services; and
- subscriber location services, and services enabled by such location capability, as an integral (designed in) attribute of any larger mobility service.

In addition, placement of this band over the 902-928 MHz unlicensed (Part 15) band allows LMS systems to exploit many features shared (or added) by Part 15 services, including:

1. greatly reduced (6-to-9 dB) pathloss and multipath dynamics relative to 2G PCS and emerging 3G mobility systems;
2. greatly simplified interoperability with Part 15 operators and equipment, e.g., in nonmultilateral segments of the LMS band (902-904 MHz and 909.75-919.75 MHz), and in guard frequencies at the edge of M-LMS bands;

3 access to low-cost subsystems, modules, and devices developed for the 902-928 MHz Part 15 band; and

Lastly, an LMS system may potentially exploit additional economies of scale due to its overlap/proximity to European GSM band (890-915 MHz, i.e., overlapping, on the GSM uplink; 935-960 MHz on the GSM downlink).

These attributes can provide the LMS service provider with strong advantages over conventional and emerging services employing 2G, 2.5G and 3G technologies. However, care must be taken to define both services and communications technology that recognize and account for the strong challenges posed in this band. In particular, the LMS service provider must account for the *co-channel interference (CCI)* generated by Part 15 users as he designs his service and business model, and as he defines, builds, and deploys his communication airlink.

Part 15 CCI will affect the network capacity and quality of service (QoS) offered in the LMS band, as well as the airlink technology required to achieve specific capacity or QoS targets. This interference can be severe, especially in large urban and suburban markets where the LMS operator may be deploying equipment in the presence of aggressive Part 15 operators. More importantly, this interference can have time and frequency characteristics that preclude use of wideband airlink technologies such as CDMA, which is the leading technology candidate for next generation mobile communications in the PCS and 3G bands. In some cases, these leading communications formats can provide as little as 1/6 the performance of more advanced technologies that are better matched to the Part 15 interference spectrum.

This is illustrated in Figures 1 and 2, illustrating capacity of a point-to-point LMS link (Base and Mobile in a macrocellular LMS network) operating in the presence of an aggressively deployed Part 15 network. Figure 1 depicts the interference and LMS communications scenarios, and plots the interference spectrum observed at the LMS Base and Mobile under this communication scenario. Figure 2 plots the spectrum of the transmit signal needed to approach the Shannon (information theoretic) capacity of the LMS link under the uplink and downlink power constraints imposed in the LMS A-M block[6], and compares capacity of the optimal frequency-selective system, an equivalent wideband format (e.g., CDMA) that is not responsive to variation in the receive interference frequency response, and a CCI-free system, e.g., obtaining after excising Part 15 CCI from the receive data signal.

The Part 15 network is assumed to provide data communications between a collection of subscribers and a network of poletops, using an FHMA modulation format with 250 kHz separation between hop channels. The poletops are distributed over a randomly perturbed hexagonal grid, with 1 km separation between nominal poletop locations, while the subscribers are randomly distributed over the deployment area. The subscriber-to-poletop node density is assumed to be 10:1 (10 subscribers serviced by each poletop), with a 10:1 asymmetry in uplink/downlink traffic (10 times as much traffic flowing downstream as upstream). The power

[6] 300 W ERP down, 30W ERP up on the 250 kHz FL segment, 30W ERP down or up on the 5.75 MHz wideband segment. This results in the well-known "water-filling" solution over channels with frequency-selective pathloss and/or background interference [DMT,IT]. An analogous approach is used in the *asymmetric digital subscriber line (ADSL)* data service.

and (for poletops) heights of all Part 15 nodes are set be within the "Safe Harbor" limits for Part 15 devices.

As Figure 1 shows, the interference received at the Base and Mobile is both strong (20 dB above the noise floor at the Mobile, and 50 dB above the noise floor at the Base) and highly frequency selective. As a consequence, the optimal transmit waveform is also highly frequency selective, such that spectrally flat modulation formats, e.g., CDMA are particularly inefficient in this band. In Figure 2, for example, link capacity drops by a factor of 3 on the LMS downlink and a factor of 6 on the LMS uplink if the transmit spectrum is constrained to have a flat over the wideband segment. More importantly, the strong interference received at the LMS Base severely limits capacity in the absence of CCI excision, such that the optimal frequency selective system can only manage 52 kbps in this scenario. [7].

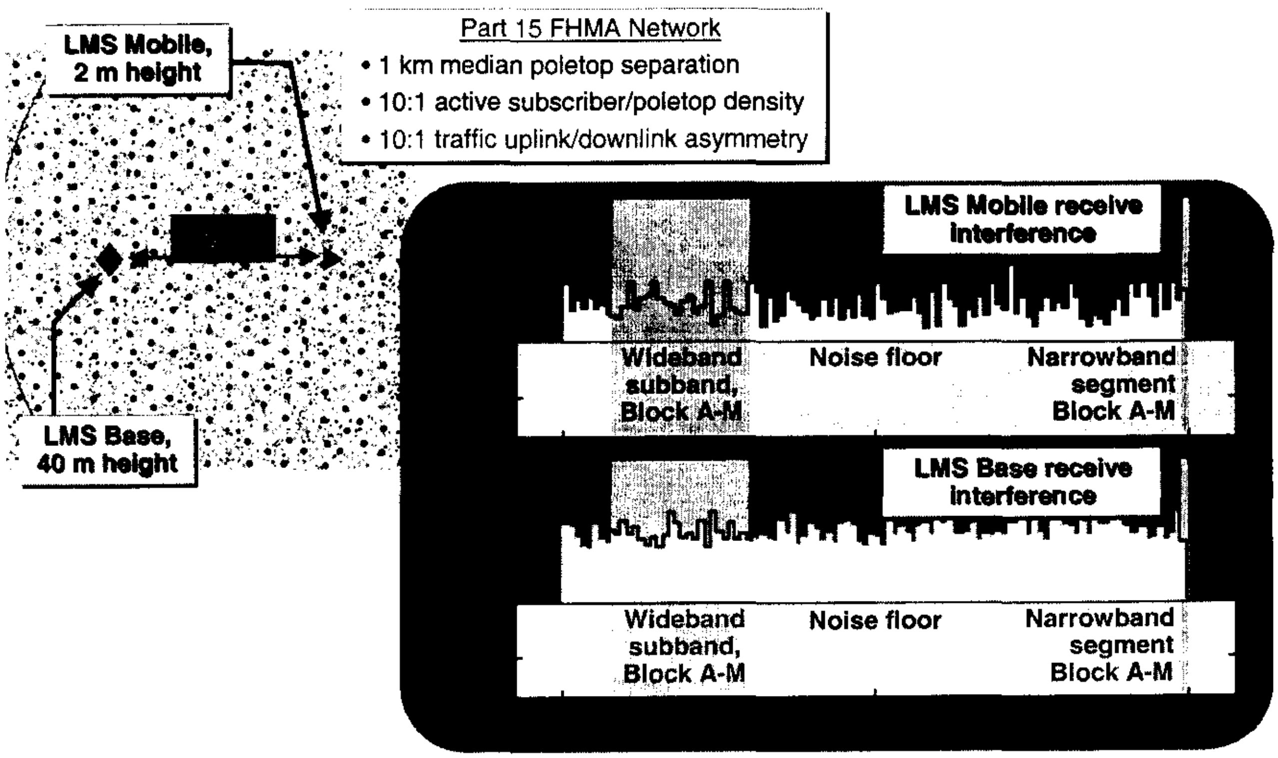

Figure 1: Receive Interference, Macrocellular M-LMS Network Scenario (Single LMS Link)

[7] In fact, this capacity is computed for a system employing the 5.75 MHz LMS A-M wideband segment (which can be implemented using CDMA modulation formats) and the 250 kHz LMS A-M FL segment. The capacity of the wideband segment by itself is 40 kbps when used for downlink transmission and *1.4 kbps* when used for uplink transmission, i.e., CDMA would practically fail in this environment.

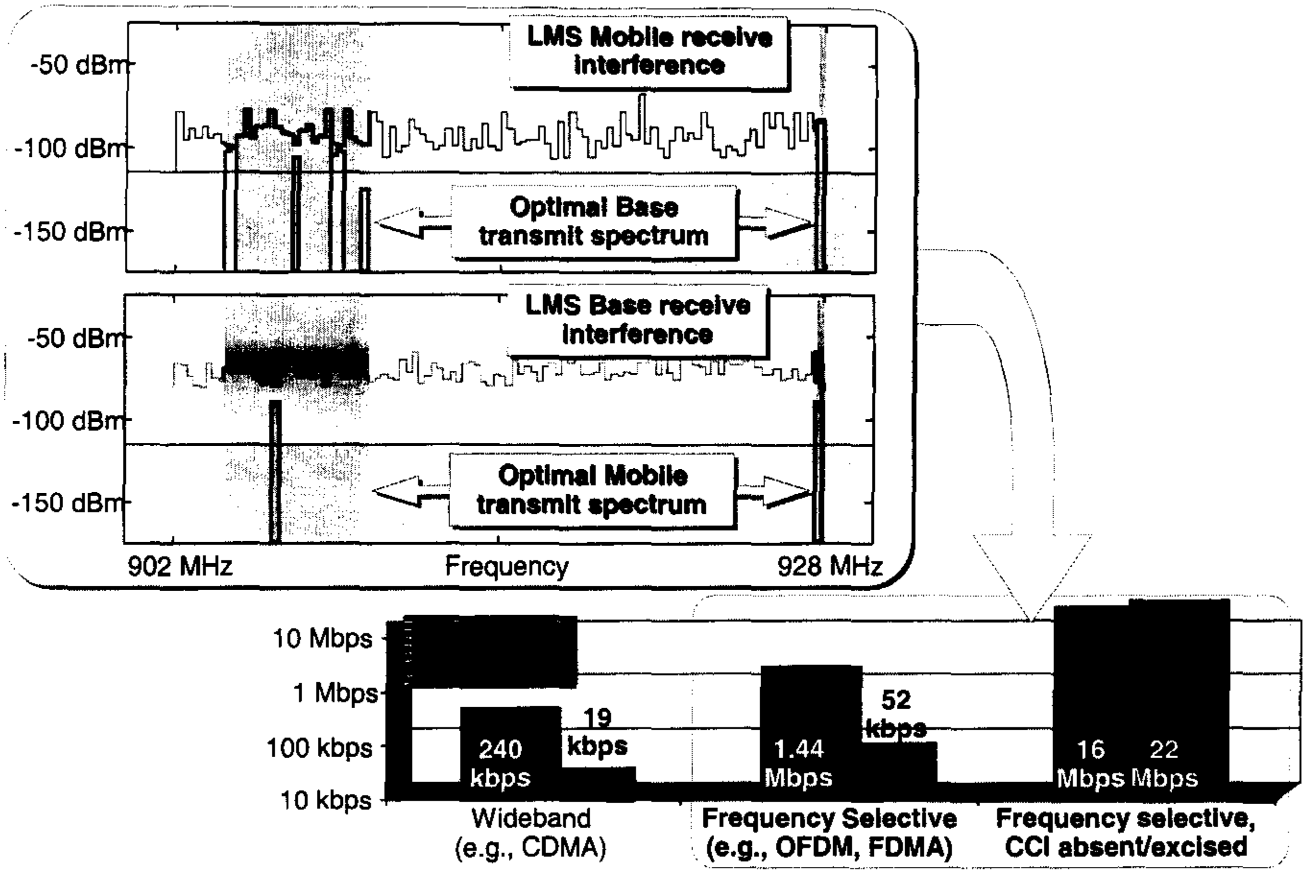

Figure 2: Receive Interference, Macrocellular M-LMS Network Scenario (Single LMS Link)

The effect of CCI is also dramatically illustrated in this Figure. In particular, downlink capacity is increased from 1.44 Mbps to 16 Mbps, and uplink capacity is increased from 52 kbps to 22 Mbps, if CCI can be removed from the Mobile and Base receive environments[8]. That is, CCI excision can increase capacity by a factor of 10 in on the system downlink, and by a factor of *400* on the system uplink!

Much higher link rates (and similar improvements over conventional wideband airlinks) can be seen in other LMS communication scenarios. This is illustrated in Figures 3 and 4, for an "LMS Microcell Network" scenario where a mobile is communicating with a poletop-based LMS Base over a 1 km range, and in Figures 5 and 6, for an "LMS Backhaul Scenario" (possible implemented as part of a microcell network) where two LMS Poletops are directly

[8]Uplink and downlink differences are due to the different ERP limits on the FL segment (300W down, 30W up).

communicating over a 2 km range. In both cases, a 15 meter antenna height is assumed for the LMS poletop, consistent with wide area or roadside network deployments.

The lower poletop height greatly reduces the density and strength of interference observed at the poletop receivers, resulting in an uplink capacity of 12 Mbps and 49 Mbps for the microcell and backhaul scenarios, respectively, in the absence of CCI excision. Removal of CCI can improve uplink capacity to 79 Mbps and 122 Mbps, or by a factor of 6 and 3, respectively, in each network scenario. These capacities are a factor of 2 higher than capacity obtainable using spectrally flat waveforms.

This analysis motivates the use of *new* modulation techniques, growing from established (TDMA-FDMA 2G) or emerging (2.5G EDGE, OFDM) airlink technologies, along with sophisticated receive-site signal processing to excise Part 15 communication signals. In this regard, frequency-selective formats provide a much stronger basis for implementation of practical CCI mitigation techniques. Frequency-selective formats allow independent excision of CCI observed on each frequency channel, greatly reducing the degrees of freedom (e.g., independent communication antennas) required to perform such excision. Frequency-selective techniques are inherently better suited to mitigation (and in fact exploitation) of channel multipath; in particular, the narrower bandwidth of individual frequency channels greatly reduces "aperture blurring" effects (channel variability across frequency) that further limits the quality and excision performance of wideband systems. Lastly, the frequency-selective formats lend themselves to channelized DSP approaches that concentrate sophisticated signal processing at the DSP backend of the system where the strongest economies of scale can be obtained, and to *fast multitarget signal separation approaches* that can use this DSP to both boost the capacity of each Base in the network (users/Base), and greatly increase throughput and concentration in packet data systems.

Waveform enhancements are also warranted to support the full range of services desired in a competitive LMS-based communication system. In particular, high quality-of-service (QoS) offerings such as committed bit-rate (CBR) service for voice and video will require additional means (not found in 2G, 2.5G, or 3G airlinks) to combat the high time variability of Part 15 interferers. In addition, none of the 2G, 2.5G, or 3G standards developed to date have sufficient modes to allow the full range of interference excision required in the LMS band.

All of these factors provide compelling motivation for introduction of true fourth generation technology in the LMS band. If done right, the LMS band can not only provide a compelling service in its own right; it will also provide a testbed for the next generation of mobility technology and services.

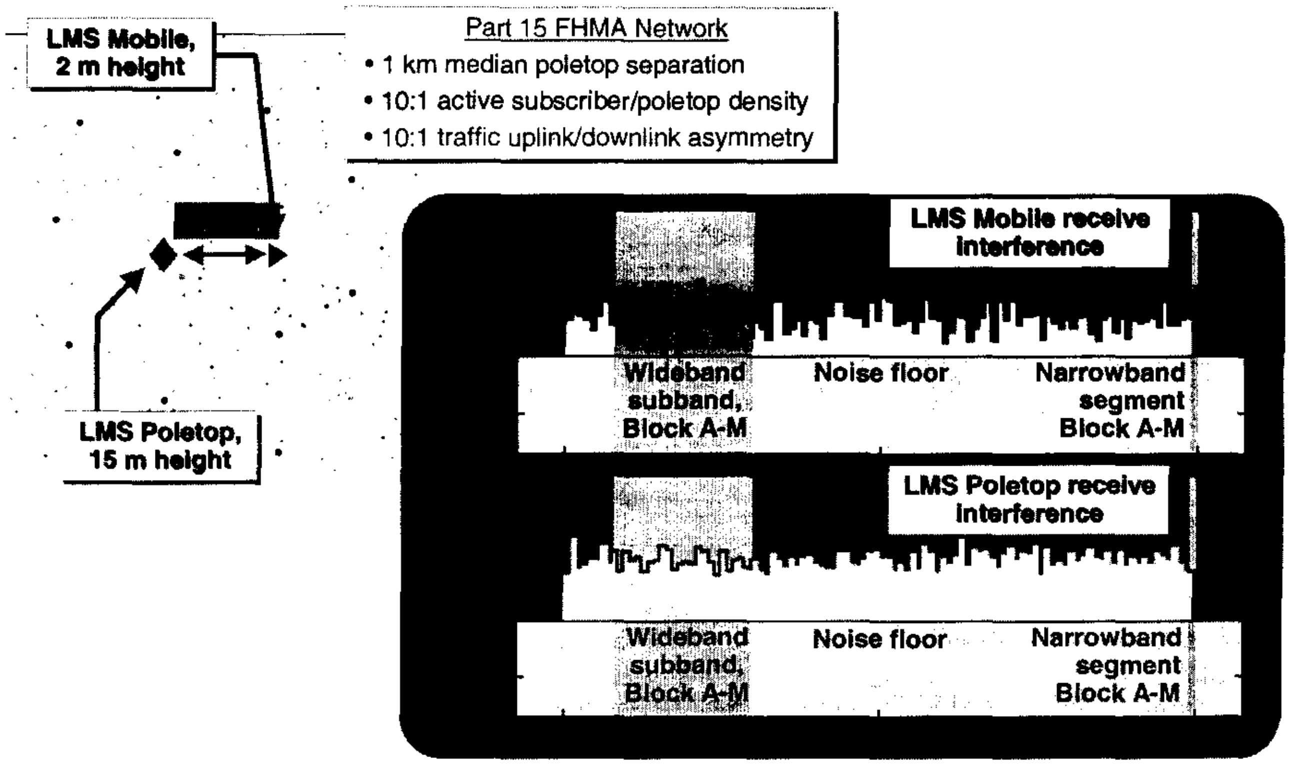

Figure 3: Receive Interference, Microcellular M-LMS Network Scenario (Single LMS Link)

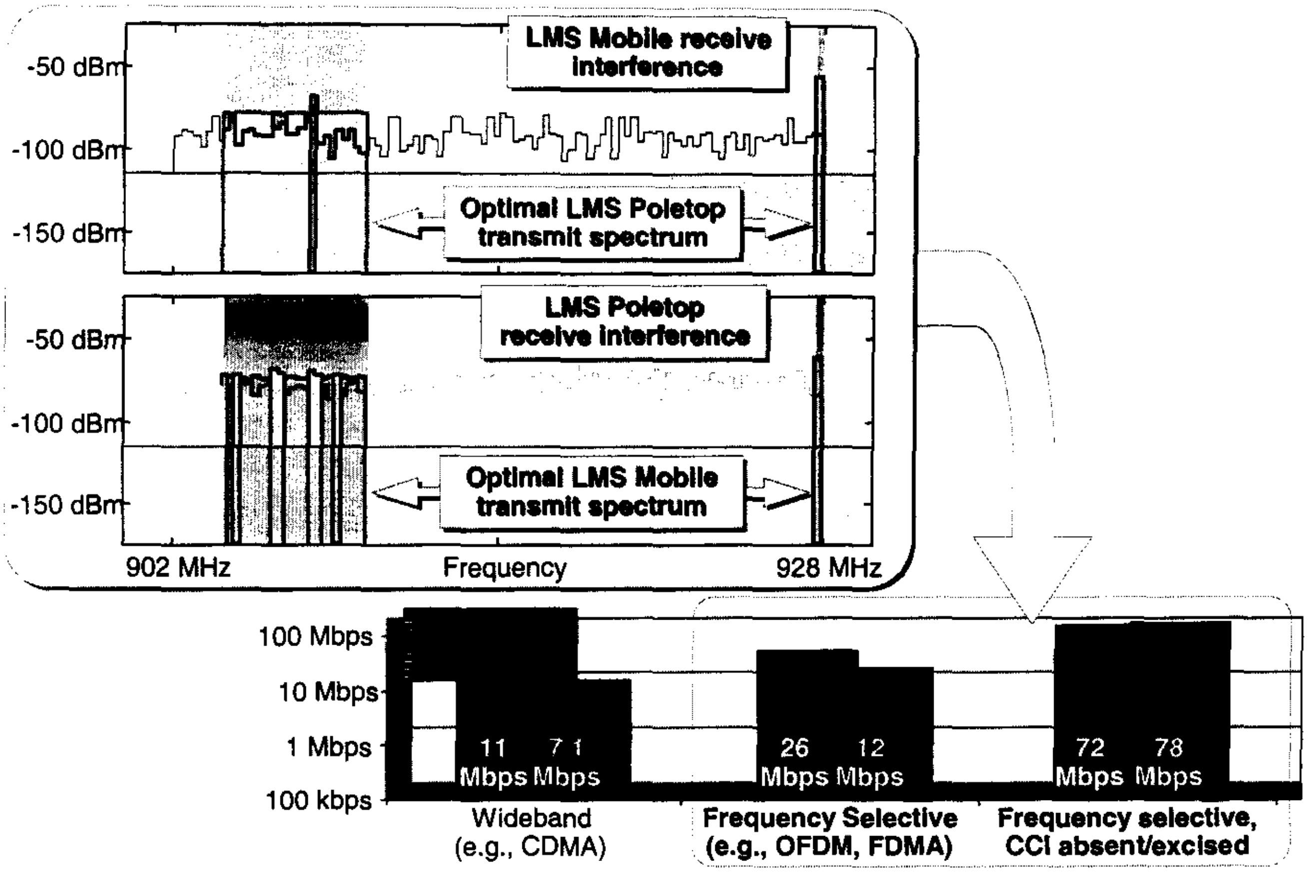

Figure 4: Receive Interference, Microcellular M-LMS Network Scenario (Single LMS Link)

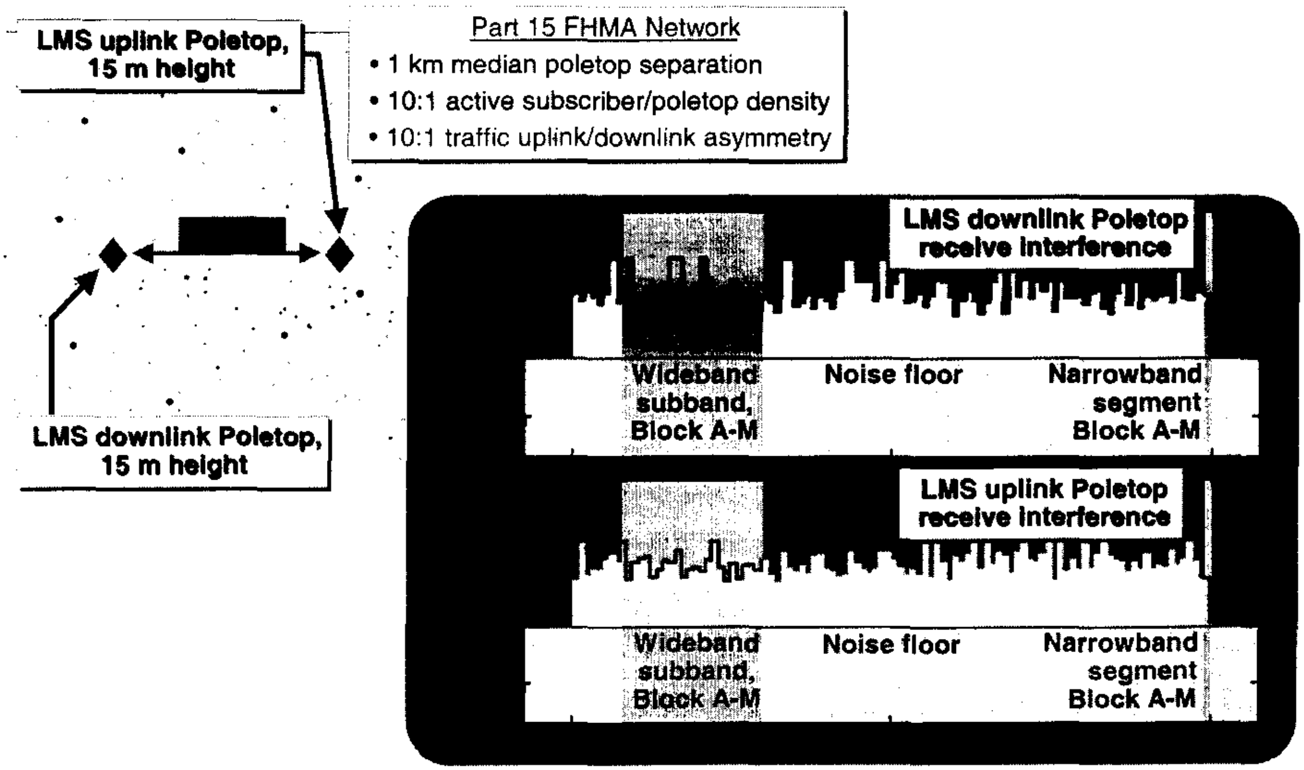

Figure 5: Receive Interference, Microcellular M-LMS Backhaul Link

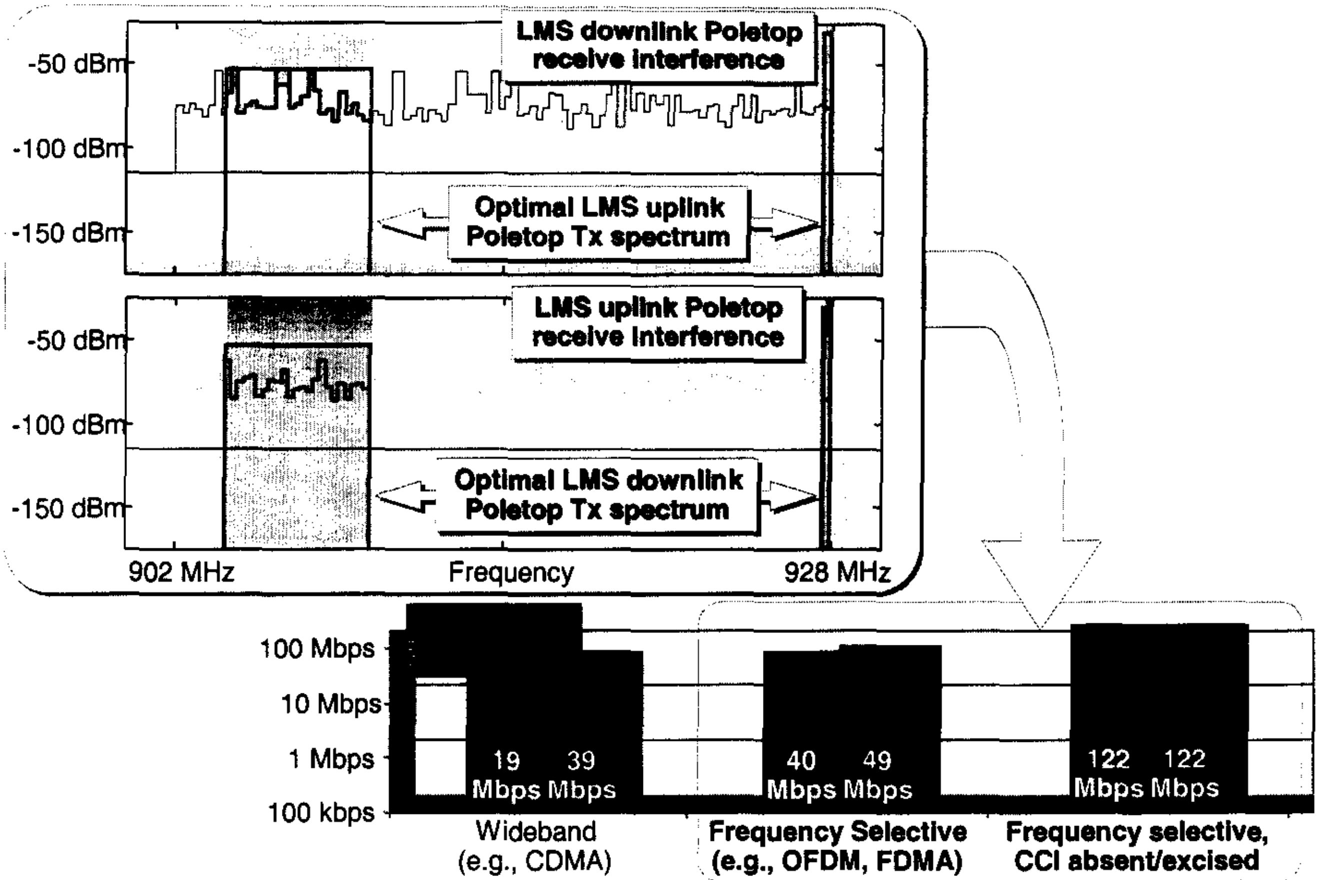

Figure 6: Receive Interference, Microcellular M-LMS Backhaul Link

2 Fourth Generation Technology Elements

Based on the analyses provided above, inherent attributes of the LMS band, and fundamental limitations of 2G-3G systems and technology, a preliminary fourth generation airlink is under development for this band. This airlink (will) possess the following technology elements.

- Time and frequency channelization, matched to the expected variability of Part 15 interference in the LMS band, and allowing exploitation of inherent benefits of narrowband modulation formats. Initial instantiations of this channelization may heavily exploit technology elements of 2G and 2.5G airlinks to minimize cost and/or time-to-market for the LMS offerings. Advanced (perhaps initial) instantiations of this technology will almost certainly use key RF elements of 2G, 2.5G, or (most likely) 3G airlinks to exploit established and emerging economies of scale for these airlinks.
- Baseband digital processing using software defined radio (SDR) methods, standards, and devices, to minimize time-to-market for the LMS system and concentrate innovation in the software-defined components of the system;
- Advanced (perhaps initial) means for instantiating time and frequency channelization, using patent pending variable-response multitone modulation that can flexibly modulate link capacity as a function of channel dynamics encountered by each link in the network, without compromising other elements of the overall communication airlink.
- GPS-based timing control at LMS Bases in the network, and robust, interference resistant synchronization methods to quickly acquire and track carrier and timing offset at mobiles in the network.
- Means for providing mobile-to-mobile service outside the network infrastructure.
- Time-division duplex (TDD) and/or TBD ad hoc single frequency networking to maximally exploit the spectrum provided in the M-LMS band.
- "High-IQ" smart antennas at Bases, microcell/roadside poletops, and high-end mobiles in the LMS network, implemented at digital baseband (i.e., over individual frequency channels and time slots), to excise strong Part 15 interference, boost network capacity, and maximize throughput and concentration of packet data users;
- Induced time and frequency redundancy to enable high quality of service applications, e.g., committed bit-rate for voice, video, and vehicle control;
- Mesh, ring, and bus network topologies, e.g., for backhaul and roadside systems, to maximize reliability, network capacity, and packet throughput through adaptive exploitation of route diversity.
- Locally enabled network optimization to continually maximize network capacity in star and nonstar cellular networks.

Initial analysis of this airlink indicates that it can deliver traffic payload at burst rates of 192 kbps full duplex (384 kbps aggregated) over 250 kHz or 320 kHz TDD links, scalable to 3 Mbps full duplex (6 Mbps aggregated) over 4 MHz of active bandwidth, e.g., within the A-M wideband segment. This capacity includes bandwidth set aside for link sync, control operations, error correction, and added filters to prevent interference with nearby nonmultilateral users (may be possible to use much more of this BW depending on specific ACI requirements of LMS band). This does *not* include inefficiency due to data fragment detection & retransmission; however, hooks have been added to allow fast (sub-millisecond if necessary) detection and acquisition of link packets, thus minimizing latency hit due to packet retransmissions. Features have also been added to allow interference excision via spatial, polarization, or time/frequency combining, and using fast, computationally efficient adaptation algorithms to maximize network and link capacity and throughput.

The baseline airlink also includes means for simply mitigating timing error of as much as 25 μs (allows implementation in microcells with 4-5 mile range), and combined carrier offset and Doppler of ± 5 kHz, or twice the carrier instability allowed under the LMS standard, in highly mobile users. The approach can also accomodate frequency and time division multiple access as well as spatial and polarization diversity, and to allow fast packet acquisition in random access data transfer applications.

Advantages of the approach are expected to be:

- data rates well in excess of rates to be provided in 2G, 2.5G, or 3G systems, particularly when combined with adaptive diversity exploitation means;
- ability to operate in the presence of strong, time and frequency variable Part 15 interference;
- ability to operate with large, time varying errors in carrier and clock sync;
- ability to pass small packets (expected to be the majority of traffic due to ITRS) quickly and without tieing up system resources;
- ability to overlay high-mobility and fixed/portable users on the same frequency channel — including ability to transition between high-mobility and fixed modes without handoff;
- ability to operate mobile-to-mobile services outside the network infrastructure;
- ability to scale up capacity at Base or mobiles using smart antennas or other diversity;
- ability to adapt power level and codec bits/symbol based on interference seen on each narrowband frequency channel (BTW, this is a fairly arbitrary channelization, and can be changed as circumstances dictate);
- ability to spread or hop over multiple time, frequency, and channel resources as interference varies in the channel.

Means for achieving these attributes have been or are in process of being captured in patents pending.
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